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ABSTRACT

In the State of Florida, the percentage of tenth grade students passing the Statewide Student Assessment Test-Part II (SSAT-II) Mathematics has declined one or two percentage points each year since 1985. Early, accurate identification and placement of these students for remedial instruction should help reverse this Florida trend. Accurate identification of these students, however, has proved to be challenging. The main purpose of this study was to determine the best combination of predictor variables that will enable educators to identify students who are likely to fail a minimum competency test in mathematics. Students included in the study were from a large urban school district. An ex post facto design and a stepwise discriminant analysis procedure were used to analyze the cognitive, biological, and school-related predictor variables selected for the study based on theory as well as the availability of valid, reliable measures. The best combination included four variables and accurately classified 88 percent of the students who failed the SSAT-II Mathematics. (Author/MH)

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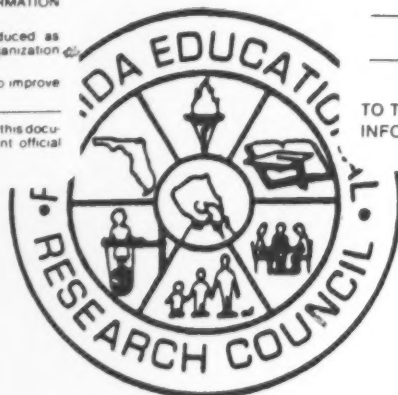
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by
Jayne Hartman

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by

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St. Lucie County District Schools

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F.E.R.C. NOTES ON THIS EDITION

With all the emphasis on mathematics education, test scores and dropouts, Jayne Hartman has given the educational community additional data which should be of great assistance to decision makers for taking advantage of predicting students with math deficiencies early enough to make some changes in curriculum and instructional techniques so they might be successful in meeting the graduation requirements. We think readers of FERC publications will benefit from Jayne Hartman's scholarly efforts.

Charlie T. Council
Executive Director

**Identifying High School Students
Likely to Fail a Minimum Competency Test
in Mathematics Required for Graduation**

EXECUTIVE SUMMARY

In the State of Florida, the percentages of tenth grade students passing the Statewide Student Assessment Test-Part II (SSAT-II) Mathematics has declined one or two percentage points each year since 1985. The purpose of the SSAT-II is to measure ability to solve everyday problems and to document whether students have mastered the Minimum Student Performance Standards (MSPS) outlined in the Florida Educational Accountability Act of 1976. Students are required to pass the SSAT-II in order to be awarded a high school diploma.

Early, accurate identification of students likely to fail the SSAT-II Mathematics should help to reverse the declining scores. Accurate identification of these students, however, has proved to be challenging. The main purpose of this study was to determine the best combination of predictor variables that will enable educators to identify students who are likely to fail a minimum competency test in mathematics.

The first task of this study was to select predictor variables of mathematics achievement on the basis of theory as well as the availability of valid measures. A review of the literature on mathematics learning and achievement identified three categories of predictor variables. The first category of predictor variables, the cognitive variables, included measures of mathematical abilities and prior mathematics achievement. The second category of predictor variables, biological variables, referred to student characteristics of age, gender, and ethnic group. The third category, school-related variables, included attendance and course of study.

Students included in the study were from a large urban school district. To obtain as representative a sample as possible, students were selected for this study using a stratified random sampling plan, blocked by gender and race. An *ex post facto* design and a stepwise discriminant analysis procedure were used to analyze the relationships among the variables and to investigate the differences between those tenth grade students who passed and those who failed SSAT-II Mathematics in March 1987.

Using a subset of four variables, 88 percent of the students who failed the SSAT-II Mathematics were accurately classified. This efficient subset included three cognitive variables (i.e., a measure of aptitude for school learning (TCS), CTBS Mathematics Concepts and Applications, and semester exam grades in mathematics classes) and one school-related variable, the ninth grade mathematics course.

A comparison of results from this study with earlier studies in predicting achievement of minimum competencies in mathematics

yields several similarities and differences. One difference suggests that it may be important to match the content of the minimum competency test to that of the norm-referenced achievement test on which predictions are based. A similarity between studies suggests that grades earned in mathematics classes do not by themselves constitute reliable indicators of students' mastery of minimum competencies, but in the company of other variables can contribute to the prediction of achievement of minimum competency in mathematics. Another similarity among these studies is the important contribution made by the aptitude measure in the prediction of minimum competencies.

Results are not consistent across the studies on the importance of attendance, or the biological variables. It seems that these variables help to describe but not to classify students who have passed or failed minimum competency tests.

The earlier prediction studies of minimum competency tests did not discuss whether there was systematic evidence of misclassification of students who passed or failed the test. For this study, white females were disproportionately represented among the students who were predicted to pass yet failed. Apparently these female students had the ability to accurately solve the SSAT-II problems as indicated by the four predictor variables, but may not have had the motivation. Possibly, including a measure of attitude about mathematics or the perceived utility of mathematics may raise the accuracy of classification for white female students.

After the main purpose of this study was accomplished, an additional research question was addressed:

1. Is a higher percentage of students correctly classified as failing SSAT-II Mathematics when item response theory (IRT) scoring method is used rather than the number-correct scoring of the standardized achievement test?

IRT scoring was expected to yield higher percentages of students correctly classified as failing or passing SSAT-II of Mathematics. This expectation was based on the evidence of smaller standard errors of measurement (SEM) with IRT scoring, particularly at the extreme lower range of scores. This expectation of higher percentages of students correctly classified using IRT scoring was not met in the present study.

ABSTRACT

In the State of Florida, the percentage of tenth grade students passing the Statewide Student Assessment Test - Part II (SSAT-II) Mathematics has declined one or two percentage points each year since 1985. Early, accurate identification and placement of these students for remedial instruction should help reverse this Florida trend. Accurate identification of these students, however, has proved to be challenging. The main purpose of this study was to determine the best combination of predictor variables that will enable educators to identify students who are likely to fail a minimum competency test in mathematics. Students included in the study were from a large urban school district. An ex post facto design and a stepwise discriminant analysis procedure were used to analyze the cognitive, biological, and school-related predictor variables selected for the study based on theory as well as the availability of valid, reliable measures. The best combination included four variables and accurately classified 88 percent of the students who failed the SSAT-II Mathematics.

Identifying High School Students Likely to Fail a Minimum Competency Test in Mathematics Required for Graduation

Concern about the quality of education and the lack of consistent and uniform academic standards has brought about legislated minimum competency testing programs (Cook, 1982; Palmer, Milton, & Fears, 1983; Popham & Lindheim, 1981; Smith, Stuck, and Johnston, 1982). Florida is among the 23 states that require students to display mastery of minimum standards prior to graduation from high school (Airasian, 1987). The Statewide Student Assessment Test - Part II (SSAT-II) for Communications and Mathematics are the tests that students are required to pass in order to be awarded a high school diploma.

The purpose of the SSAT-II is to document whether students have mastered the Minimum Student Performance Standards (MSPS) outlined in the Florida Educational Accountability Act of 1976. Each section of the SSAT-II measures one standard, communications or

mathematics. Each standard is defined by 15 skills and each skill is measured by five test questions. The SSAT-II is intended to be of equal difficulty from year to year. Test scores are reported in terms of a score scale equated to the scale of tests administered in October 1978 with a score of 700 set as the required minimum score for passing. Students initially are administered the SSAT-II in March of their sophomore year. Students who do not pass both sections of the SSAT-II may take the failed section(s) again in October and March their junior and senior years. Thus, students are given five opportunities before graduation to show mastery of the functional skills assessed on the SSAT-II.

In 1977, following the enactment of the 1976 Educational Accountability Act, the State of Florida enacted a Compensatory Education Program to provide direct remedial instruction to students at risk of failing the SSAT-II. In spite of this assistance, the percentage of tenth grade students in the state who pass the SSAT-II Mathematics in their initial administration has been declining. In 1985, 84 percent of the students passed SSAT-II Mathematics; in 1986, 83 percent passed; in 1987, 82 percent passed. Early, accurate identification of these students for remedial instruction should help to reverse this trend in Florida.

Accurate identification of these students, however, has proved to be challenging. A large urban school district in Florida presently uses the mathematics test of the Comprehensive Tests of Basic Skills ([CTBS] CTB/McGraw-Hill, 1981) as the criterion measure for selecting tenth grade students for its Compensatory Education Mathematics Program. The CTBS is a norm-referenced, objectives-based standardized achievement test which is administered to ninth graders in the district each spring. The selection criterion score for the past two years has been the 30th national percentile based on number-correct scoring. Using this criterion, however, only one-half of the tenth grade students who failed SSAT-II Mathematics in March 1987 were identified for the Compensatory Education Mathematics Program. The remaining one-half who failed SSAT-II Mathematics had CTBS national percentile scores higher than 30, so they were not selected for the remedial program and failed to receive the needed assistance. In an effort to help this district increase the percentage of at-risk students correctly identified, this study was undertaken.

There are three likely reasons the district's current selection procedure is not adequate for identifying students at risk of failing the SSAT-II Mathematics. First, a single predictor variable is being used rather than a set of predictor variables. The CTBS represents achievement in basic skill areas at only one particular time and should be

considered along with other variables which based on theory and past research, predict mathematics achievement.

A second possible limitation of the current selection criterion is that traditional number-correct scoring rather than item response theory (IRT) scoring is used. In IRT scoring, a computer is used to calculate a student's scale score by applying an iterative algorithm directly to the item responses. Since IRT scoring uses more information from each item than number-correct scoring, the IRT standard errors of measurement (SEM) are always the same as or smaller than the corresponding number-correct SEM. A smaller SEM is particularly important for classifying students with lower test scores because the SEM is larger towards the ends of the scale than it is near the middle of the range. Thus, the increased accuracy using IRT scoring may improve classification of students with lower scores.

A third factor in accurately identifying potential students for a remediation program is that a much higher percentage of black students than white students fail the SSAT-II Mathematics, yet the cut-off score is based on the total population which is predominantly white. Hypothetically, a common prediction equation for the combined groups may systematically overpredict or underpredict subgroup performance. Differential prediction studies address the possibility of generating separate prediction equations which most accurately identify students within each group.

Research Questions

This study sought to provide answers to the following research questions:

1. What is the best combination of existing predictor variables to maximize differences between students who pass SSAT-II Mathematics and students who fail?
2. Is a higher percentage of students correctly classified as failing SSAT-II Mathematics when the item response theory (IRT) scoring method is used rather than the currently employed method of number-correct scoring of the standardized achievement test?
3. Does the prediction equation accurately classify black students or should a separate prediction equation be used to identify black students who are likely to fail SSAT-II Mathematics?

The principal tasks of this study were to (a) select predictor variables of mathematics achievement on the basis of theory as well as the availability of valid measures, (b) determine the set of existing predictor variables that correctly classified the highest percentage of students who failed SSAT-II Mathematics, (c) investigate whether IRT scoring of the CTBS measures increases the percentage of students currently classified to fail SSAT-II Mathematics, and (d) assess the accuracy of classifying black students using the best combination of predictor variables for a representative sample and for a black sample.

To achieve the first task, the literature on mathematics learning and achievement was reviewed to identify predictor variables. Then these variables were matched to available, valid measures for the study. Three categories of variables including cognitive, biological, and school-related variables were investigated in the study. The cognitive variables include measures of mathematical abilities, and prior mathematics achievement. The biological variables refer to the student characteristics of age, gender and ethnic group. The school-related variables include attendance and course of study. Although these variables at first appear exclusive, research indicates that they are confounded and the biological variables cannot be separated from cognitive and school-related variables when studying mathematics achievement (Begle, 1979; Fennema, 1984; Matthews, 1984; Reyes & Stanic, 1985).

Relationship Between Student Variables and Mathematics Achievement

Cognitive Variables

Begle (1979) conducted a review of empirical and factual information which exists about the effects of various variables on student learning in mathematics. From this review, he concluded that "the best predictor of mathematics achievement is previous mathematics achievement" (p. 97). With regard to other cognitive variables, Begle (1979) found that intelligence resulted in a significant positive correlation with mathematics achievement, while reading and spatial visualization resulted in positive but not significant correlations with mathematics achievement. However, "only rarely does any other cognitive variable (other than previous mathematics achievement) contribute significantly to prediction" (Begle, p. 97).

Biological Variables

Gender. Extensive reviews of the research on gender-related differences have concluded that while girls outperform boys on computation skills (Begle, 1979), as a group, males outperform females in higher-level mathematics tasks (Begle, 1979; Benbow & Stanley, 1982; Fennema, 1984). Fennema (1984) found that gender differences in mathematics increase as the difficulty level of mathematics increases and Armstrong (1985) concluded that gender differences are greatest in mathematics application and problem-solving skills.

Race or ethnic group. Differences in mathematics achievement also have been identified for race or ethnic groups. Reviews have consistently indicated that Blacks, Hispanics, and American-Indian students do less well in mathematics than Anglo and Oriental students but that this difference is growing smaller (Anick, Carpenter, & Smith, 1981; Begle, 1979; Johnson, 1984; Matthews, 1984; Matthews, Carpenter, Lindquist, & Silver, 1984; Patchen, 1982).

Age. As these gender and ethnic group differences appear, females and minority students are retained to a greater extent than white males. Pedretty (1987) investigated whether age distinguished students who passed a minimum competency test in mathematics from those who failed. She reported that among students who passed the test, nine percent were overage -- more than one year older than the modal age for their grade placement. In sharp contrast, 43 percent of the students who failed were overage. Furthermore, the highest percentage of overage students was found for black males (63%), followed by black females (46%), white males (41%), and white females (30%).

School-related Variables

Mathematics learning takes place largely in the classroom setting (Wolf, 1979) and follows a developmental pattern in that rapid development continues throughout the school years (Bloom, 1964). Therefore, mathematics achievement may be directly influenced by course taking and attendance in mathematics courses.

Course taking. Course taking has received much attention in studies of mathematics and minorities. Consistent results have indicated that female students and black students traditionally have enrolled in fewer optional mathematics courses than white male students (Fennema, 1984). Moreover, students who enroll in optional mathematics courses achieve at a higher level than those who do not (Meece et al. 1982), and blacks are more likely to be enrolled in lower-level mathematics courses (Matthews, 1984).

Attendance. Since absences not only reduce the amount of schooling time but cause a disruption in the sequence of learning, attendance

also seems to be related to mathematics achievement. Monk and Ibrahim (1984) studied mathematics achievement and patterns of absence for individual students and for classes. In addition to the number of days absent, the timing of absences and the number of separate episodes of absences were monitored. Since many of their results were inconclusive, they could only speculate that absenteeism might be a consequence of the activities and atmosphere of the school setting.

Jackson (cited in Matthews, 1984) did find that school setting, attendance, and mathematics achievement were interrelated. He found that black students were more likely to have lower mathematics achievement scores in schools in which there were attendance problems.

Research on Predicting Failure on Minimum Competency Tests in Mathematics

Several cognitive, biological, socio-cultural, and school-related variables have been used by researchers in studies which attempted to identify students likely to fail high school competency mathematics tests (Jonas & Hayes-Wallace, 1986; Lynch, 1982; Smith et al., 1982). Using multivariate analysis procedures, researchers did identify factors that predicted students' future performance on these competency tests. In the Jonas and Hayes-Wallace (1986) study, 86 percent of the students were correctly classified as passing or failing Georgia's state high school exit exam using grade-point average and norm-referenced test scores from the cognitive variable category, and self-concept scores from the Piers-Harris Children's Self-Concept Scale, a socio-cultural variable.

In the Smith et al. (1982) study, 81 percent of the students were correctly classified to pass or fail the North Carolina Competency Test using cognitive variables of mathematics computation and mechanical reasoning and the school-related variables of average school attendance and first grade teachers' ratings in industriousness and courtesy. Biological variables of gender and ethnic group did not contribute to the prediction of success or failure on the test.

Lynch (1982) performed a regression analysis and found that the cognitive variables of ability test scores and grade point average, the

biological variables of age and ethnic group, and the school-related variable of course of study contributed to the prediction of performance on the minimum competency test in mathematics administered in Illinois. Gender, a biological variable, and attendance, a school-related variable, were not significantly related to performance on this test.

Method

Based on previous research of variables shown to be related to mathematics performance, measures of mathematics achievement, reading comprehension, and academic aptitude from the cognitive category; age, gender, and ethnic group from the biological category; and attendance and mathematics course of study from the school-related category of variables were selected for the study. Table 1 presents a brief description of the variables and the labels which will be used in the tables of results.

Table 1

Labels for Predictor Variables

Category	Variable Label	IRT Scored Variable Label	Description
Cognitive (Previous Mathematics Achievement)	CA	CAI	CTBS Concepts and Applications
	COMP	COMPI	CTBS Computation
	MATH	MATHI	CTBS Total Math
	SK8		SSAT-I (Grade 8) Skills
	ST8		SSAT-I (Grade 8) Standards
	QTACH		Nine-Weeks Achievement Grades in Mathematics Course
	SEMACH		Semester Achievement Grades in Mathematics Course
	SEMEX		Semester Exam Grades in Mathematics Course

<u>Cognitive</u> (Other)	READ	READI	CTBS Reading Comprehension
	TCS		Test of Cognitive Skills

Table 1 (continued)

Category	Variable Label	IRT Scored Variable Label	Description
<u>Biological</u>	AGE ETHNIC GENDER		Race or Ethnic Group
<u>School Related</u>	ABS		Days Absent from Mathematics Classes
	COURSE		Ninth Grade Mathematics Course

An ex post facto design was used to analyze these existing variables to determine the relationship between the criterion measure, SSAT-II Mathematics, and combinations of these selected predictor variables. Discriminant analysis was the statistical procedure used to analyze the relationship among the variables and to investigate the differences between those tenth grade students who passed and those who failed SSAT-II Mathematics in March 1987.

Setting

Hillsborough County is located on the west coast of Florida in the central part of the state. With a 1987-88 enrollment approaching 118,000 students in grades K-12, Hillsborough County public schools is the twelfth largest school system in the United States and the third largest in Florida. Since the federal court ordered desegregation in 1971, the school system has been desegregated due to cross-busing and housing patterns.

Sample

To obtain as representative a sample as possible, students were selected for this study using a stratified random sampling plan -- blocked by gender and race or ethnic group. That is, the gender and racial balance in the sample's two groups (i.e., passing, failing) matched the gender and racial balance in the population. Six hundred students were included in the sample: three hundred students who failed SSAT-II Mathematics and 300 students who passed. Choosing large and equal sample sizes was important to ensure that the analysis was robust despite possible violations to the underlying assumptions of multivariate analysis (Tabachnick & Fidell, 1983).

A second sample of black students was selected to address the third research question: Does the prediction equation accurately classify black students or should a separate prediction equation be used to identify black students likely to fail SSAT-II Mathematics? To address this question, 300 black students (18% of the black population) were included: one hundred fifty black students who failed SSAT-II Mathematics and 150 black students who passed. The sample size was determined by at least 20 cases for each predictor variable (Tabachnick & Fidell, 1983). In addition, it was important to have equal sample sizes to ensure robustness of the analysis. To be representative of the black population, the proportion of males and females in the passing and failing groups in the black population was maintained for the black sample.

Only students with complete data sets were included in the study. If students were selected initially without complete data sets, they were replaced with students of the same ethnic and gender categories and with the same SSAT-II Mathematics scores. This substitution rather than elimination of students with missing data helped to ensure the representativeness of the sample.

Instrumentation

The cognitive measures of previous mathematics achievement (Grade 8 SSAT-I Mathematics, CTBS Form U, Level J Mathematics, and achievement and semester exam grades in mathematics courses), reading comprehension (CTBS Form U, Level J Reading Comprehension) and academic aptitude (Test of Cognitive Skills [TCS], CTB/McGraw-Hill, 1981) selected for the study were evaluated using the Educational and Psychological Testing (APA, 1985) and are considered to be valid and reliable measures.

Data Analysis Procedures

The stepwise method of discriminant analysis was selected to limit the effect of multicollinearity. In addition to entering all predictor variables, a forward selection approach recommended by Huberty and Wisenbaker (1988) was used with subsets of variables to explore whether fewer predictor variables enhance predictive accuracy. For both the complete and hierarchical stepwise procedures, a cross-validation was conducted to determine the stability of the classification functions with a second, comparable sample of students.

Before conducting discriminant analysis, data were screened for outliers and evaluated for the underlying assumption of multivariate procedures: linearity, normality, and homogeneity of variance-covariance matrices. Procedures recommended by Tabachnick and Fidell (1983) were followed to identify and change outliers and to evaluate the assumptions.

Results

Research Question 1

What is the best combination of existing predictor variables to maximize differences between students who pass SSAT-II Mathematics and students who fail?

Stepwise Discriminant Analysis Results

Table 2 shows the results of the stepwise method of discriminant analysis with all variables eligible for entering the equation. On the basis of the ten variables that met the criterion to enter (Wilk's Lambda), there was statistically significant discrimination between the two groups $\chi^2(10) = 262.50, p .01$. The square of the canonical correlation (.698) indicates that about 49 percent of the variance is shared by the linear combination of these variables. It is important to note that neither the CTBS measure of Reading Comprehension (READ) nor days absent (ABS) met the criterion to enter the equation.

Table 2

Results of Complete Stepwise Discriminant Analysis for Representative Sample

Step	Predictor Variable	Standardized Coefficient	Structure Coefficient	F-to-Remove
1	CTBS MATH	-.6636	.78	
2	SSAT-I SK8	.2733	.68	9.8970
3	ETHNIC	.2987	-.36	16.506
4	TCS	.1889	.73	3.4930
5	COURSE	.2032	.70	3.9607
6	SEMEX	.1932	.42	5.4749
7	AGE	-.1742	-.33	5.2368
8	GENDER	-.1665	-.06	4.9115
9	CTBS CA	.6552	.78	6.2808
10	(CTBS MATH)			
11	CTBS COMP	.4060	.71	5.9346
12	CTBS MATH			3.7399
	Canonical R	.6980		
	Eigenvalue	.9502		

	Percentage of Students Correctly Classified		
	Fail	Pass	Overall
Initial Classification	85.5	84	84.75
Cross-Validation	83	86	84.5

NOTE. Variable removed is shown in parentheses.

As shown at the bottom of Table 2, 85.5 percent of the students in the analysis phase were correctly classified as failing; 83 percent of the students who failed were correctly classified in the cross-validation phase, indicating little shrinkage. Shrinkage is the tendency for predictive validities to decrease when a predictive model developed on one sample is applied to another (new) sample not used to derive the classification coefficients.

Hierarchical Discriminant Analysis Results

In addition to entering all predictor variables, discriminant analysis procedures were conducted with subsets of predictor variables in order to explore whether fewer predictor variables enhance predictive accuracy. The following forward selection approach suggested by Huberty and Wisenbaker (1988) was used.

A direct discriminant function analysis and cross-validation study were performed on each pair of predictor variables to assess predic-

tion of membership in the FAIL and PASS groups. To each pair which correctly classified at least 80 percent of the students who failed, each of the remaining variables was added, in turn, and a stepwise discriminant function analysis and a cross-validation were performed on each triplet of predictor variables. To each triplet which correctly classified at least 80 percent of the students who failed, each of the remaining variables was added in turn, and a stepwise discriminant function analysis and a cross-validation were performed on each quartet of predictor variables. These procedures were followed to identify the remaining best subsets.

Table 3 shows the cross-validation results for the best subsets. Variables for each subset are presented in the order in which they entered the analysis. It is interesting to note that as more variables enter the equation, the accuracy of the classification for students who failed SSAT-II Mathematics tends to decline while the accuracy for students who passed tends to increase.

Table 3

Percentages of Correct Classifications in the Cross-Validation for the Best Subsets of Predictor Variables for Representative Sample

Subset Size	Best Subset	Percentage of Correct Classifications		
		Fail	Pass	Overall
2	CA SEMACH	84	81	82.5
3	CA COURSE SEMEX	86	81	83.5
4	CA TCS COURSE SEMEX	88	82	85
5	CA TCS AGE SEMACH GENDER	87	82	84.5
6	CA TCS AGE SEMACH GENDER QTACH	87	82	84
7	CA TCS AGE SEMACH GENDER QTACH MATH	88	82	85
8	MATH TCS AGE GENDER COMP CA SEMACH QTACH	84	87	84.5
9	MATH TCS ST8 GENDER AGE COMP CA SEMACH QTACH	85	84	84.5
10	MATH SK8 TCS GENDER AGE SEMACH CA (MATH) COMP MATH QTACH ST8	85	87	86

NOTE. Variable removed is shown in parentheses.

For the purpose of this study, the accurate identification of students likely to fail is the focus. With subsets of four and seven predictor variables, 88 percent of the students who failed were classified correctly. Therefore, the most empirically efficient set of

variables for accurately classifying students who failed SSAT-II Mathematics includes CTBS Mathematics Concepts and Applications (CA), TCS, ninth grade mathematics course (COURSE), and grades on semester exams in these courses (SEMEX). In the initial analysis phase, 87 percent of the students who failed SSAT-II Mathematics were classified correctly as failing, indicating a high degree of consistency in the classification scheme.

On the basis of the four predictor variables in the most efficient subset, there was statistically significant discrimination between the two groups, $\chi^2(4) = 219.61$, $p .01$. The square of the canonical correlation (.652) indicates that about 43 percent of the variance is shared by the linear combination of these four variables in the best subset.

Discriminant analysis results for these four variables are presented in Table 4. The standardized discriminant function coefficients, which may be interpreted as standardized beta weights in the regression context, reflect the unique contribution of each variable to the discriminant function. Based on the standardized coefficients, the variables, when in the company of the others, would be ordered relative to importance in the following way: CTBS CA, COURSE, TCS, SEMEX.

Table 4

Results of Discriminant Function Analysis of the Best Combination of Predictor Variables for Representative Sample

Step	Predictor Variable	Standardized Coefficient	Structure Coefficient	F-to-Remove
1	CTBS CA	.3927	.88	12.937
2	TCS	.2974	.83	8.0359
3	COURSE	.3842	.79	14.690
4	SEMEX (Grades)	.2200	.48	6.6483
	Canonical R	.652		
	Eigenvalue	.741		

Predictor Variable	Univariate F (1,398)	Pooled Within-Group Correlation Between Predictors		
		TCS	COURSE	SEMEX
CTBS CA	228.9	.63	.58	.36
TCS	201.5		.55	.31
COURSE	183.3			.06
SEMEX (Grades)	67.75			

While 85 percent accurate classification of students is impressive, the remaining misclassified students, those predicted to pass yet failed and those predicted to fail yet passed, were of interest. Among the students who failed SSAT-II Mathematics but were predicted to pass, white females were disproportionately represented ($N=20$, 53%). Other students who were misclassified and failed included seven black females, six white males, and five black males.

For students who passed SSAT-II Mathematics but were predicted to fail, the percentages by ethnic and gender categories mirror those of the passing sample. That is, of the students who were predicted to fail yet passed, one-third were white females, one-third were white males, and the remaining one-third included twice the number of blacks than Hispanics.

Most students who were misclassified had scores on SSAT-II Mathematics near the cut-off passing score of 700. As one might expect, students with extreme high or low scores were classified correctly. Toward the middle of the score distribution, however, the percentage of incorrect classifications increased. The highest percentage of misclassified failing students (26%) occurred in the highest score range for failing students (690-699) and all lower score ranges had no more than ten percent misclassifications. Likewise, for students predicted to pass, the highest percentage of misclassifications (55%) occurred in the lowest passing score interval (700-709), with a sharp increase in classification accuracy above this borderline level.

Research Question 2

Is a higher percentage of students correctly classified as failing SSAT-II Mathematics when the IRT-scoring method is used rather than the currently employed method of number-correct scoring of the standardized achievement test?

Stepwise Discriminant Analysis Results

Table 5 shows the results of the stepwise method of discriminant analysis with CTBS measures using IRT scoring and the other predictor variables eligible for entering the equation. On the basis of the eight variables that met the criterion to enter (Wilk's Lambda), there was statistically significant discrimination between the two groups, $\chi^2(8) = 258.10$, $p .01$.

Table 5

Results of Complete Stepwise Discriminant Analysis Using IRT
Scoring of CTBS Measures for Representative Sample (N=400)

Step	Predictor Variable	Standardized Coefficient	Structure Coefficient	F-to-Remove
1	CTBS MATHI	.3011 (.6636)	.83 (.78)	6.2824 (3.7399)
2	SSAT-I SK8	.3079 (.2733)	.69 (.68)	13.042 (9.8970)
3	ETHNIC	-.2857 (-.2987)	-.36 (-.36)	15.161 (16.506)
4	TCS	-.1792 (.1889)	.74 (.73)	3.1534 (3.4930)
5	AGE	-.1850 (-.1742)	-.33 (-.33)	5.8875 (5.2368)
6	GENDER	-.1733 (-.1665)	-.06 (-.06)	5.3619 (4.9115)
7	SEMEX (Grades)	.1864 (.1932)	.43 (.42)	4.9598 (5.4749)
8	COURSE	.2116 (.2032)	.71 (.70)	4.0268 (3.9607)
	Canonical R	.6933 (.6980)		
	Eigenvalue	.9253 (.9502)		

	Percentage of Students Correctly Classified		
	Fail	Pass	Overall
Initial Classification	85.5 (85.5)	85 (84)	85.25 (84.75)
Cross-Validation	82 (83)	87 (86)	84.5 (84.5)

NOTE: Results for number-correct scoring are shown in parentheses for comparison.

Comparing these results to those in Table 3 with CTBS measures using number-correct scoring, one can see that the first variable selected was CTBS Total Mathematics (MATH or MATHI) and the same variable was selected at steps two (SSAT-I SK8), three (ETHNIC), and four (TCS). At steps five through eight the same four variables (AGE, GENDER, SEMEX, and COURSE) entered the two prediction equations but not in the same order. A final similarity between the two equations for the different scoring methods is that neither the CTBS measure of Reading Comprehension (READ AND READI) nor the school-related variable of days absent (ABS) met the eligibility criterion to enter the prediction equations.

The major difference between the equations is that with number-correct scoring, CTBS Mathematics Concepts and Applications (CA) entered at step nine, CTBS MATH was removed at step 10, CTBS Mathematics Computation (COMP) entered at step 11, and CTBS MATH reentered at step 12. With IRT scoring of CTBS measures, CTBS CAI and COMPI did not enter the prediction equation. The

stronger relationship between pairs of CTBS measures with IRT scoring and among CTBS measures and other cognitive and school-related variables may explain the reason that CAI and COMPI did not meet the criterion to enter the analysis or to cause the removal of MATHI. Moreover, MATHI had the highest correlation with SSAT-II Mathematics ($r = .78$) and was the most important predictor by itself to predict group membership as indicated by its univariate F ratio.

The same percentage of students (85.5%) initially was classified correctly as failing SSAT-II Mathematics with number-correct scoring and IRT scoring. A slightly higher percentage of students (85%) initially was correctly classified as passing with IRT scoring than with number-correct scoring (84%). Results are slightly more stable, however, with number-correct scoring as evidenced by 83 percent correctly classified as failing in the cross-validation compared to 82 percent for the IRT scoring.

Regarding the relative importance of variables that entered the equations, results for IRT scoring are consistent with those from number-correct scoring. Based on the standardized and structure coefficients, the primary variables in distinguishing between students who failed SSAT-II Mathematics and students who passed were the intercorrelated cognitive variables of CTBS Total Mathematics (MATHI), TCS, and SSAT-I skills achieved at grade eight (SK8), as well as the school-related variable of ninth grade mathematics course (COURSE). The F-to-Remove indicates that ETHNIC, a biological variable, is of most importance after adjusting for all other variables in the analysis.

Hierarchical Discriminant Analysis Results

Table 6 shows the initial classification and cross-validation results for the best subsets with number-correct scoring and with IRT scoring. For many subsets, the percentage of students correctly classified as passing SSAT-II Mathematics is slightly higher with IRT scoring than with number-correct scoring. In contrast, the percentage of students correctly classified as failing in the cross-validation is slightly higher with number-correct scoring. Of most importance, however, is that with IRT scoring the percentage of students correctly classified as failing does not reach 88 percent, which is the percentage correctly classified for the most efficient subset of variables with number-correct scoring of CTBS Mathematics Concepts and Applications (CA), TCS, COURSE, and SEMEX. With IRT scoring, the most efficient subset includes these same four variables.

Table 6

Percentages of Correct Classifications in the Cross-Validation for the Best Subsets of Predictor Variables Using Number-Correct Scoring and IRT Scoring of CTBS Measures for Representative Sample

NUMBER CORRECT SCORING					IRT SCORING			
		Percentage of Correct Classifications					Percentage of Correct Classifications	
Size	Best Subset	Fail	Pass	Overall	Best Subset	Fail	Pass	Overall
2	CA SEMACH	84	81	82.5	CAI SEMACH	83	83	83
3	CA COURSE SEMEX	86	81	83.5	CAI COURSE SEMEX	86	83	84.5
4	CA TCS COURSE SEMEX	88	82	85	CAI TCS COURSE SEMEX	87	83	85
5	CA TCS AGE SEMACH GENDER	87	82	84.5	CAI ETHNIC TCS SEMEX COURSE	85	81	83
6	CA TCS AGE SEMACH GENDER QTACH	87	82	84	CAI TCS ST8 COURSE SEMEX GENDER	87	84	85.5
7	CA TCS AGE SEMACH GENDER QTACH MATH	88	82	85	CAI TCS ST8 COURSE SEMEX GENDER COMPT	86	84	85
8	MATH TCS AGE GENDER COMP CA SEMACH QTACH	85	84	84.5	CAI TCS ST8 COURSE SEMEX AGE GENDER COMPT	85	85	85
9	MATH TCS ST8 GENDER AGE COMP CA SEMACH QTACH	85	84	84.5	CAI ETHNIC ST8 TCS AGE SEMEX COURSE GENDER COMPT	84	83	83.5
10	MATH SK8 TCS GENDER AGE SEMACH CA QMATH COMPT QACH ST8	85	87	86				

NOTE. Variable removed is shown in parentheses.

Research Question 3

Does the prediction equation accurately classify black students or should a separate prediction equation be used to identify black students who are likely to fail SSAT-II Mathematics?

Stepwise Discriminant Analysis Results

Table 7 shows the results of the stepwise method of discriminant analysis for the black sample. With all variables eligible for entering the equation, six variables met the criterion to enter resulting in statistically significant discrimination between the two groups, $\chi^2(6) = 91.058$, $p .01$. The square of the canonical correlation indicates that about 37 percent of the variance is shared by the linear combination of these variables. As shown at the bottom of the table, 78 percent and 82 percent of the students in the black sample were correctly classified as failing in the analysis phase and cross-validation phase, respectively.

Table 7

Results of Complete Stepwise Discriminant Analysis for Black Sample (N=200)

Step	Predictor Variable	Standardized Coefficient	Structure Coefficient	F-to-Remove
1	COURSE	.5392	.76	15.681
2	SEMEX (Grades)	.3108	.42	6.7232
3	CTBS READI	.3069	.71	5.0676
4	AGE	-.2668	-.46	4.4502
5	GENDER	-.2699	-.08	4.9403
6	SSAT-I SK8	.1612	.59	6.7232
	Canonical R	.6108		
	Eigenvalue	.5952		

	Percentage of Students Correctly Classified		
	Fail	Pass	Overall
Initial Classification	78	74	76
Cross-Validation	82	76	79

The standardized coefficient, structure coefficient, and F-to-remove at the last step support the importance of COURSE to distinguish between black students who failed and black students who passed SSAT-II Mathematics. The second most important variable is Reading Comprehension with IRT scoring (READI) based on the structure coefficients; either READI or grades on district-wide semester exams in ninth grade mathematics courses (SEMEX) based on standardized coefficients; either SEMEX or SSAT-I skills mastered at grade eight (SK8) based on Fs-to-remove.

COURSE, SEMEX, and SSAT-I SK8 were also important variables in the prediction equation for the representative sample. In addition, the two biological variables of GENDER and AGE met the criterion to enter the equation for both the black sample and representative sample. In contrast, Reading Comprehension (READ and READI) did not enter the equation for the representative sample. Instead, the CTBS measures of mathematics (CA, COMP, MATH; MATHI) and TCS entered the equations and were considered relatively important predictor variables in discriminating between students who passed and failed SSAT-II Mathematics for the representative sample.

The 100 black students selected for the cross-validation sample were classified also using the discriminant function derived by the complete stepwise method for the representative sample. Table 8 shows the percentage of these students correctly classified using the analysis with number-correct scoring and with IRT scoring of the CTBS measures. Forty-eight of the 50 black students (96%) who failed were correctly classified by both scoring methods of CTBS measures as failing. However, slightly less than half the black students who passed were classified correctly by both scoring methods as passing. Thus, the complete stepwise analysis for the black sample yields higher overall correct classification while the prediction equation for the representative sample results in a higher percentage of correct classification for black students who failed but a much lower percentage for black students who passed SSAT-II Mathematics.

Table 8

Percentages of Black Students Correctly Classified Using Prediction Equation for Representative Sample (N=100)

	Percentage of Students Correctly Classified		
	Fail	Pass	Overall
Number-Correct Scoring of CTBS Measures	96	46	71
IRT Scoring of CTBS Measures	96	48	72

Hierarchical Discriminant Analysis Results

Huberty and Wisenbaker's (1988) procedure for identifying the best subsets of predictor variables was conducted also for the black sample. Table 9 shows these best subsets and the percentages of black students who were classified correctly in the cross-validation phase.

Table 9

Percentages of Black Students Correctly Classified in the Cross-Validation Using Prediction Equations for Black Sample and Representative Sample

Size	Best Subset	BLACK SAMPLE Percentage of Correct Classifications			Best Subset	REPRESENTATIVE SAMPLE Percentage of Correct Classifications		
		Fail	Pass	Overall		Fail	Pass	Overall
2	COURSE QTACH	84	66	75	CAI SEMACH	74	76	70
3	COURSE MATHI QTACH	84	74	79	CAI COURSE SEMEX	92	70	81
4	COURSE SEMACH MATHI QTACH	85	68	76.5	CA TCS COURSE SEMEX	84	66	75
5	COURSE SEMACH GENDER MATHI QTACH	84	70	77	CA TCS AGE SEMACH GENDER	88	62	75
6	COURSE AGE GENDER SEMACH QTACH MATHI	82	72	77	CA TCS AGE SEMACH GENDER QTACH	86	64	75
7					CA TCS AGE SEMACH GENDER QTACH MATH	86	64	75
8					MATH TCS AGE GENDER COMP CA SEMACH QTACH	84	66	75
9					MATH TCS ST8 GENDER AGE COMP CA SEMACH QTACH	84	64	74
10					MATH SK8 TCS GENDER AGE SEMEX CA (MATH) COMP QTACH ST8	80	66	73

NOTE. Variable removed is shown in parentheses.

As shown in Table 9, the best subset for predicting black students who failed includes four variables: ninth grade mathematics course (COURSE), semester achievement grades in the course (SEMACH), CTBS Total Mathematics with IRT scoring (MATHI), and nine-week or quarter achievement in the ninth grade mathematics course (QTACH). Eighty-five percent of the black students in the cross-validation phase who failed SSAT-II Mathematics were correctly classified using the prediction equation based on these four variables (COURSE, SEMACH, MATHI, QTACH). With regard to overall accuracy, 79 percent of the black students were classified correctly as either failing or passing SSAT-II Mathematics with three of these variables: COURSE, MATHI, and QTACH.

The 100 black students selected for the cross-validation sample also were classified using the prediction equations for the best subsets for the representative sample. Also shown in Table 9, the highest percentage of black students correctly classified as failing (92%) and overall (81%) are for the subset of three variables: CTBS Mathematics Concepts and Applications with IRT scoring (CAI), COURSE, and SEMEX. It is important to note that four variables (CA, TCS, COURSE, and SEMEX) were included in the best subset for correctly classifying the representative sample. Thus, a higher percentage of black students was correctly classified using a discriminant function derived on the representative sample than on the

black sample. However, of the best subsets derived from the representative sample, one was best classifying the representative sample and another for classifying the black sample.

Discussion

Using a combination of variables related to mathematics achievement and either the complete stepwise discriminant analysis procedure or the Huberty and Wisenbaker (1988) forward selection procedure resulted in significantly improving the early identification of students in this school district who failed SSAT-II Mathematics. The complete stepwise analysis procedure resulted in classifying correctly 83 percent of the subgroup of students who failed SSAT-II Mathematics and in classifying correctly 84.5 percent of the total sample of students. With this complete analysis, all variables but CTBS Reading Comprehension and attendance in mathematics classes met the eligibility criterion to enter the discriminant analysis.

The most accurate classification, however, resulted from using the Huberty and Wisenbaker (1988) forward selection procedure. This procedure yielded a subset of four variables that would be used to classify accurately 88 percent of the students who failed SSAT-II Mathematics and 85 percent of the total sample of students who passed or failed. The subset of four variables included three cognitive variables -- a measure of aptitude for school learning (TCS), CTBS Mathematics Concepts and Applications, and semester exam grades in mathematics classes -- and one school-related variable, the ninth grade mathematics course.

Using either an accuracy of classifications or an efficiency criterion for selecting an analysis procedure, the Huberty and Wisenbaker forward selection procedure was superior in this study. It required fewer variables to obtain the most accurate classifications for both the failing group and the total sample of students.

A comparison of results from the present study with earlier studies on predicting achievement of minimum competencies in mathematics (Jonas & Hayes-Wallace, 1986; Lynch, 1982; Smith et al., 1982) yields several similarities and differences. The most obvious consistency is that more than 80 percent of the students in the

studies which employed discriminant analysis (the present study; Jonas & Hayes-Wallace, 1986; Smith et al., 1982) were classified correctly using a combination of predictor variables.

With regard to the cognitive variables, in the present study CTBS Mathematics Concepts and Applications was the subtest which matched more closely the content of SSAT-II Mathematics and was among the four variables of the best subset of predictor variables. In contrast, even though the CTBS Mathematics Concepts and Applications subtest was included among the predictor variables, scores from the CTBS Mathematics Computation subtest entered the prediction equation in the Smith et al. (1982) study on the North Carolina Competency Test. Possibly, their minimum competency test placed a greater emphasis on computation than application of problem-solving skills. If so, the difference between their results and results from the present study suggests that it may be important to match the content of the minimum competency test to that of the norm-referenced achievement test on which predictions will be based.

In addition to norm-referenced measures of previous achievement, the present study and one other (Lynch, 1982) included course grades as a potential predictor variable. In the Lynch study, grade point average (GPA) contributed to the accurate prediction of mathematics performance on the Illinois minimum competency test. In this study, grades on the semester exams, and nine-week and semester achievement grades in mathematics classes were included as potential predictors. Each of these measures was moderately correlated with SSAT-II Mathematics but was unable by itself to predict group membership as evidenced by their univariate *F* ratios. Grades on semester exams in mathematics courses entered the complete stepwise discriminant analysis as well as the best subset of predictor variables. Since these measures of achievement in mathematics classes had strong intercorrelations, nine-week and semester achievement grades did not enter either of these prediction equations.

The findings related to achievement grades in mathematics courses suggest that grades earned in mathematics classes are not by themselves consistent, reliable indicators of students' mastery of minimum competencies, but in the company of the other variables can contribute to the prediction of performance of SSAT-II Mathematics. This inconsistency somewhat substantiates the public's cry for evidence of students' mastery of minimum competencies prior to graduation. Apparently, it is possible for students to earn passing grades in mathematics courses without having mastered minimum skills in mathematics.

A third finding related to cognitive variables that is similar in the present study and two others (Lynch, 1982; Smith et al., 1982) is that an aptitude measure was an important variable in the accurate classification of students. According to Begle (1979), only rarely does any cognitive variable besides previous mathematics achievement contribute significantly to prediction. This conclusion was drawn from research on general mathematics achievement. Perhaps, when achievement of minimum competencies in mathematics is the focus for prediction, aptitude measures for school learning should be included among the potential predictor variables.

The school-related variable, course of study, was used in two studies, the present study and Lynch's (1982), and it was observed to be an important predictor variable in both. Thus, it appears that students enrolled in lower-level mathematics courses are much more likely to fail minimum competency tests than students enrolled in higher-level mathematics courses, as one might anticipate.

The other school-related variable, attendance, was considered in the present study and in both the Lynch (1982) and Smith et al. (1982) studies. Results were not consistent across these three studies. In the Smith et al. (1982) prediction study, attendance was an important predictor. Conversely, in this study and the Lynch (1982) study attendance did not contribute to the accurate prediction of students' performance on a minimum competency test; yet, the average days absent for students who failed was higher than for students who passed.

Results also are not consistent across the studies regarding the importance of the biological variables in predicting performance on minimum competency tests in mathematics. Previous research has indicated that biological variables are confounded and cannot be separated from socio-cultural and school-related variables when studying mathematics achievement.

In the Smith et al. (1982) study, neither gender nor race was an important variable but the school-related variable of attendance contributed to the discrimination between students likely to pass and fail the North Carolina Competency Test. In the Lynch study (1982), ethnic group and age were important variables as well as the school-related variable of course of study; gender did not meet the criterion to enter the regression equation. In this present study, not one of the biological variables was in the best subset of predictor variables while a school-related variable of course of study was an important variable.

The results of the study related to biological variables support earlier research in that biological variables were not found in themselves to be good predictors. It seems that biological variables, and

perhaps attendance, help to describe but not to classify students who have passed or failed minimum competency tests. Indeed, proportionately more females than males, blacks and Hispanics than whites and Orientals, and older students failed SSAT-II Mathematics. However, many older, black females with poor attendance in mathematics classes passed this test and were classified correctly because of their scores on the four variables in the best subset of predictor variables.

The earlier prediction studies of minimum competency tests did not discuss whether there was systematic evidence of misclassification of students who passed or failed the test. In the present study, for the most part students who were misclassified had SSAT-II Mathematics scores near the cut-off score of 700. That is, students who failed but were predicted to pass mainly had SSAT-II scores between 690 and 700; students who passed yet were predicted to fail mainly had scores between 700-729.

These latter misclassifications are of little concern since these students would probably benefit from the remedial program they received as a result. Of greater concern is the students who fail but are predicted to pass and therefore, would not be identified for remedial assistance. Studies should be designed to predict failure of minimum skills for the sample of students who passed and failed the minimum competency test in mathematics yet had scores within the uncertain range around the cut-off score. Using only these students as the total sample might help identify variables that enable much finer discrimination between two groups of students who appear quite similar in performance on a mathematics minimum competency test.

Among the students who failed SSAT-II Mathematics but were predicted to pass, white females were disproportionately represented. These students were similar to students who passed with regard to the four predictor variables: mathematics course in which they were enrolled during ninth grade and semester exams grades in that course as well as performance on CTBS Mathematics Concepts and Applications and the measure of aptitude for school learning (TCS) administered in the spring of their ninth grade year. Yet, the following year, they failed the SSAT-II Mathematics. Meece et al. (1982) concluded that gender differences in attitude and mathematics achievement may be influenced by sex role expectations and gender identity, while Anderson (1982) stated that peer values have a strong influence on student achievement. Matthews (1984) concluded that female students are less likely than males to understand how mathematics is useful in everyday life or how it will be useful in their future jobs. Since the SSAT-II Mathematics measures ability to solve everyday mathematical problems, possibly

these female students had the ability but not the motivation to accurately solve these problems. Predictor variables in the present study did not include a measure of attitude about mathematics or the perceived utility of mathematics. A study should be conducted using measures of attitudes about mathematics among the predictor variable to determine whether white female students could more accurately be identified as likely to fail a minimum competency test in mathematics.

IRT Scoring Versus Number-Correct Scoring of CTBS

Compared to number-correct scoring, IRT scoring of CTBS measures was expected to yield higher percentages of students correctly classified as failing or passing SSAT-II Mathematics. This expectation was based on the evidence of smaller standard errors of measurement (SEM) with IRT scoring, particularly at the extreme lower and upper ranges of scores.

This expectation of higher percentages of students correctly classified as passing or failing the SSAT-II Mathematics using IRT scoring of CTBS measures was not met in the present study. Results from the complete stepwise discriminant analysis were the same for IRT scoring and number-correct scoring with regard to overall accuracy of correctly classifying 84.5 percent of the students as either passing or failing SSAT-II Mathematics. A minor difference, however, is noted between IRT scoring and number-correct scoring results by group. A slightly higher percentage of students who failed SSAT-II Mathematics was classified correctly with number-correct scoring than IRT scoring of CTBS measures (83% and 82%, respectively) whereas a slightly higher percentage of students who passed SSAT-II Mathematics was classified correctly with IRT scoring than number-correct scoring of CTBS measures (87% and 86%, respectively).

Results from the hierarchical discriminant analysis for number-correct scoring and IRT scoring of CTBS measures were consistent with those from the complete stepwise analyses. That is, a slightly higher percentage of students who failed was classified correctly with number-correct scoring than with IRT scoring (88% and 87%, respectively) while a slightly higher percentage of students who passed was classified correctly with IRT scoring than number-correct scoring (83% and 82%, respectively). Overall, 85 percent of

the students were classified correctly as either passing or failing SSAT-II Mathematics using the best subset of variables with number-correct scoring or IRT scoring of CTBS measures.

The finding that number-correct scoring of CTBS measures leads to more accurate classifications of students who failed SSAT-II Mathematics than IRT scoring suggests that number-correct scoring of norm-referenced achievement measures may be preferred when predicting performance on minimum competency tests. The practical benefits of this finding are that, with number-correct scoring, test results are more easily interpreted by teachers and more easily explained to students and parents.

Separate Prediction Equation for Black Students

A slightly higher percentage of black students who failed SSAT-II Mathematics was correctly classified with a separate prediction equation for the black sample than with the equation for the best subset of four predictor variables for the representative sample. However, using the best subset of three variables for the representative sample, an even higher percentage of black students was correctly classified. Thus, it appears that a separate equation does more accurately predict black students who failed, but this equation is derived on the representative sample rather than the black sample.

The percentages of students who were classified correctly as failing SSAT-II Mathematics in the black and representative sample was 92 percent and 88 percent, respectively. These data are from the best subsets of predictor variables. Based on the results from the complete stepwise discriminant analysis procedure for the representative sample, 96 percent of the black students who failed were classified correctly but less than half the black students who passed were correctly classified. This finding demonstrates that it is necessary to explore whether a general prediction equation accurately predicts scores for minority students. With the best set of predictor variables for correctly classifying black students, 30 percent of the students who passed were classified incorrectly as failing. There could be several reasons for this high percentage of incorrect classifications for black students who passed. First, black students' passing scores on SSAT-II Mathematics tend to be near the cut-off score of 700, within the range that was most often misclassified in the representative sample. Second, one could speculate that these black

students who were predicted to fail yet passed benefited from effective instruction during their tenth grade year prior to the March administration of SSAT-II Mathematics.

A third possible reason for the misclassifications of black students who passed is suggested by the finding that the most important predictor variables were ninth grade mathematics course and CTBS Mathematics Concepts and Applications. It appears that many of these misclassified black students were in lower-level ninth grade mathematics courses and subsequently had low scores on the CTBS test, yet were able to show mastery of the minimum competencies the following year. The implication of this finding is that black students who have aptitude for higher-level mathematics courses need to be identified and encouraged to enroll and achieve in these courses. Matthews (1984) indicated that black students tend to like mathematics and that schools should help black students to appreciate the utility of mathematics in their everyday lives and to overcome their perception of mathematics as a white domain.

The relationship between reading comprehension and mathematics achievement found for the representative sample was even stronger for the black sample. In fact, in the complete stepwise discriminant analysis procedure for the black sample, reading comprehension was the only CTBS measure among the six predictor variables to enter the prediction equation.

The importance of reading comprehension in the present study for black students is inconsistent with previous research. Begle (1979) found that reading resulted in positive but not significant correlations with mathematics achievement and that it would not contribute significantly to prediction of mathematics achievement. Probably, this is because the relationship between reading comprehension and mathematics achievement is confounded by the relationship between reading comprehension and previous mathematics achievement -- the best predictor of mathematics achievement. However, that reading comprehension was found to be an important predictor of mathematics achievement for black students in this study suggests that black students' ability to solve mathematical problems is inhibited to a greater extent by their limited acquisition of linguistic and factual knowledge to translate mathematical problems or by their limited verbal abilities to comprehend language in sentences and paragraphs. The extent to which reading comprehension is related to the linguistic and factual knowledge required to translate mathematical problems should be investigated as well as effective instructional strategies to assist students in acquiring this knowledge.

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